Claims

I claim:

1. A power module, comprising:

an air compressor cell defining a variable-volume air compressor chamber, an air supply port, and an air exit port, said air supply port and air exit port each arranged in fluid communication with the air compressor chamber, said air supply port adapted to communicate with a source of supply air;

an air supply valve associated with the air supply port and selectively operable to move between i) a closed position at which the air supply valve closes the air supply port and thereby closes fluid communication between the source of supply air and the air compressor chamber via the air supply port and ii) an opened position at which the air supply valve opens the air supply port and thereby opens fluid communication between the source of supply air and the air compressor chamber via the air supply port;

an air pump piston positioned in the air compressor chamber and operable to move between i) an expansion position at which the air compressor chamber reaches its maximum volume and ii) a contraction position at which the air compressor chamber reaches its minimum volume;

a combustion cell defining a variable-volume combustion chamber separate from the air compressor chamber, an air intake port, and an exhaust port, said air intake port and exhaust port each arranged in fluid communication with the combustion chamber;

an air storage chamber arranged in fluid communication between the air exit port of the air compressor cell and the air intake port of the combustion cell;

an intake valve associated with the air intake port of the combustion cell and selectively operable to move between i) a closed position at which the intake valve closes the air intake port and thereby closes fluid communication between the air storage chamber and the combustion chamber via the air intake port and ii) an opened position at which the intake valve opens the air intake port and thereby opens fluid communication between the air storage chamber and the combustion chamber via the air intake port;

an exhaust valve associated with the exhaust port of the combustion cell and selectively operable to move between i) a closed position at which the exhaust valve closes the exhaust port and thereby closes fluid communication between the combustion chamber and the exhaust port and ii) an opened position at which the exhaust valve opens the exhaust port and thereby opens fluid communication between the combustion chamber and the exhaust port; and

a power piston positioned in the combustion chamber and operable to move therein between i) an expansion position at which the combustion chamber reaches its maximum volume and ii) a contraction position at which the combustion chamber reaches its minimum volume.

2. The power module of claim 1, further including an air check valve arranged in fluid communication between said air exit port of the air compressor cell and the air storage chamber, said air check valve operable to allow only one-way fluid flow from the air compressor chamber to the air storage chamber.

3. The power module of claim 1, wherein said air supply valve is a electronically-controllable two-way valve including a movable magnetically-latchable poppet having an end portion, a return spring operable to bias the poppet towards one position corresponding to the closed position of the air supply valve, and an opening-direction electrical coil located proximate the end portion of the poppet, said opening-direction electrical coil selectively operable to electromagnetically pull the poppet towards another position corresponding to the opened position of the air supply valve.

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4. The power module of claim 3, further including an electronic control unit operable to selectively and independently control the operation of the air supply valve with digital pulses of electrical current.

5. The power module of claim 4, further including an air pressure sensor operable to sense the pressure of air in the air storage chamber and provide the electronic control unit with a signal indicative of such pressure, said electronic

control unit operable to move the air supply valve to its opened position in response to said pressure being below a threshold air pressure, said electronic control unit operable to move the air supply valve to its closed position in response to said pressure being at least the threshold air pressure.

6. The internal combustion of claim 5, wherein the control unit is operable to selectively and independently control the operation of the air supply valve in further response to at least one sensed parameter selected from the group of ambient air temperature, ambient barometric pressure, inlet air temperature, inlet air pressure, actuating fluid temperature, actuating fluid pressure, throttle position, power piston position, engine brake signals, starter inputs, and ignition switch position.

7. The power module of claim 1, wherein the air compressor cell and the combustion cell are integrally formed adjacent one another by a common housing.

8. The power module of claim 1, wherein the air pump piston and the power piston are movable by a common drive device.

9. The power module of claim 8, wherein said common drive device includes a rotatable crankshaft.

10. The power module of claim 1, further including a direct-injection fuel injector extending into the combustion chamber and selectively operable to inject fuel therein.

11. A power module, comprising:

a turbocharger including an exhaust gas inlet and a compressed air outlet;

an air compressor cell defining a variable-volume air compressor chamber, a free air supply port adapted to communicate with atmosphere, at least one turbocharged air supply port arranged in fluid communication with the compressed

air outlet of the turbocharger, and an air exit port, said free air supply port, turbocharged air supply port, and air exit port each arranged in separate fluid communication with the air compressor chamber;

a free air supply valve associated with the free air supply port and selectively operable to move between i) a closed position at which the air supply valve closes the air supply port and thereby closes fluid communication between atmosphere and the air compressor chamber via the free air supply port and ii) an opened position at which the free air supply valve opens the free air supply port and thereby opens fluid communication between atmosphere and the air compressor chamber via the free air supply port;

a turbocharged air supply valve associated with each turbocharged air supply port and selectively operable to move between i) a closed position at which the turbocharged air supply valve closes its respective turbocharged air supply port and thereby closes fluid communication between the compressed air outlet of the turbocharger and the air compressor chamber via the respective turbocharged air supply port and ii) an opened position at which the turbocharged air supply valve opens its respective turbocharged air supply port and thereby opens fluid communication between the compressed air outlet of the turbocharger and the air compressor chamber via the respective turbocharged air supply port;

an air pump piston positioned in the air compressor chamber and operable to move between i) an expansion position at which the air compressor chamber reaches its maximum volume and ii) a contraction position at which the air compressor chamber reaches its minimum volume;

a combustion cell defining a variable-volume combustion chamber separate from the air compressor chamber, an air intake port, a free exhaust port adapted to communicate with atmosphere, and at least one drive exhaust port arranged in fluid communication with the exhaust gas inlet of the turbocharger, said air intake port, free exhaust port, and drive exhaust port each arranged in separate fluid communication with the combustion chamber;

an air storage chamber arranged in fluid communication between the air exit port of the air compressor cell and the air intake port of the combustion cell;

an intake valve associated with the air intake port of the combustion cell and selectively operable to move between i) a closed position at which the intake valve closes the air intake port and thereby closes fluid communication between the air storage chamber and the combustion chamber via the air intake port and ii) an opened position at which the intake valve opens the air intake port and thereby opens fluid communication between the air storage chamber and the combustion chamber via the air intake port;

a free exhaust valve associated with the free exhaust port of the combustion cell and selectively operable to move between i) a closed position at which the free exhaust valve closes the free exhaust port and thereby closes fluid communication between the combustion chamber and atmosphere via the free exhaust port and ii) an opened position at which the free exhaust valve opens the free exhaust port and thereby opens fluid communication between the combustion chamber and atmosphere via the free exhaust port;

a drive exhaust valve associated with each drive exhaust port of the combustion cell and selectively operable to move between i) a closed position at which the drive exhaust valve closes its respective drive exhaust port and thereby closes fluid communication between the combustion chamber and the exhaust gas inlet of the turbocharger via the respective drive exhaust port and ii) an opened position at which the drive exhaust valve opens its respective drive exhaust port and thereby opens fluid communication between the combustion chamber and the exhaust gas inlet of the turbocharger via the respective drive exhaust port; and

a power piston positioned in the combustion chamber and operable to move therein between i) an expansion position at which the combustion chamber reaches its maximum volume and ii) a contraction position at which the combustion chamber reaches its minimum volume.

12. A power module, comprising:

an actuating fluid compressor cell defining a variable-volume actuating fluid compressor chamber and an actuating fluid port arranged in fluid communication with the actuating fluid compressor chamber, said actuating fluid port adapted to communicate with a source of actuating fluid;

an actuating fluid drain passage adapted to be arranged in fluid communication with the source of actuating fluid;

an actuating fluid supply valve arranged in fluid communication between the source of actuating fluid and the actuating fluid port and selectively operable to move between i) a closed position at which the supply valve closes fluid communication between the source of actuating fluid and the actuating fluid compressor chamber via the actuating fluid port and ii) an opened position at which the supply valve opens fluid communication between the source of actuating fluid and the actuating fluid compressor chamber via the actuating fluid port;

an actuating fluid pump piston positioned in the actuating fluid compressor chamber and operable to move therein between i) an expansion position at which the actuating fluid compressor chamber reaches its maximum volume and ii) a contraction position at which the actuating fluid compressor chamber reaches its minimum volume;

a combustion cell defining a variable-volume combustion chamber, separate from the actuating fluid compressor chamber, an air inlet port, an exhaust port, and an actuating fluid common rail, said air inlet port and exhaust port each arranged in fluid communication with the combustion chamber;

an actuating fluid storage chamber arranged in fluid communication between the actuating fluid port of the actuating fluid compressor cell and the actuating fluid common rail;

a hydraulically-actuatable intake valve associated with the air inlet port of the combustion cell and having an actuating fluid chamber and a piston portion positioned in the actuating fluid chamber, said intake valve selectively operable to move between i) a closed position at which the intake valve closes the air inlet port and thereby closes fluid communication to the combustion chamber via the air inlet port and ii) an opened position at which the intake valve opens the air inlet port and thereby opens fluid communication to the combustion chamber via the air inlet port;

an electronically-controllable magnetically-latchable first control valve arranged in fluid communication between the actuating fluid common rail and the actuating fluid chamber of the intake valve, said first control valve selectively operable to move between i) a closed position at which the first control valve closes

fluid communication between the actuating fluid common rail and the actuating fluid chamber of the intake valve and opens fluid communication between the actuating fluid drain passage and the actuating fluid chamber of the intake valve thereby allowing the intake valve to be moved towards its closed position and ii) an opened position at which the first control valve opens fluid communication between the actuating fluid common rail and the actuating fluid chamber of the intake valve and closes fluid communication between the actuating fluid drain passage and the actuating fluid chamber of the intake valve thereby allowing the intake valve to be hydraulically moved towards its opened position ;

a hydraulically-actuatable exhaust valve associated with the exhaust port of the combustion cell and having an actuating fluid chamber and a piston portion positioned in the actuating fluid chamber, said exhaust valve selectively operable to move between i) a closed position at which the exhaust valve closes the exhaust port and thereby closes fluid communication between the combustion chamber and the exhaust port and ii) an opened position at which the exhaust valve opens the exhaust port and thereby opens fluid communication between the combustion chamber and the exhaust port;

an electronically-controllable magnetically-latchable second control valve arranged in fluid communication between the actuating fluid common rail and the actuating fluid chamber of the exhaust valve, said second control valve selectively operable to move between i) a closed position at which the second control valve closes fluid communication between the actuating fluid common rail and the actuating fluid chamber of the exhaust valve and opens fluid communication between the actuating fluid drain passage and the actuating fluid chamber of the exhaust valve thereby allowing the exhaust valve to be moved towards its closed position and ii) an opened position at which the second control valve opens fluid communication between the actuating fluid common rail and the actuating fluid chamber of the exhaust valve and closes fluid communication between the actuating fluid drain passage and the actuating fluid chamber of the exhaust valve thereby allowing the exhaust valve to be hydraulically moved towards its opened position; and

a power piston positioned in the combustion chamber and operable to move therein between i) an expansion position at which the combustion chamber reaches its maximum volume and ii) a contraction position at which the combustion chamber reaches its minimum volume.

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13. The power module of claim 12, further including a check valve arranged in fluid communication between the actuating fluid port of the actuating fluid compressor cell and the actuating fluid storage chamber, said check valve operable to allow only one-way fluid flow from the actuating fluid compressor chamber to the actuating fluid storage chamber.

14. The power module of claim 12, wherein said actuating fluid supply valve includes a digitally-controlled two-way valve including a movable magnetically-latchable spool having one end portion and an opposite end portion, a closing-direction electrical coil located proximate the one end portion of the spool, and an opening-direction electrical coil located proximate the opposite end portion of the spool, said closing-direction electrical coil selectively operable to electromagnetically pull the spool towards one state corresponding to the closed position of the actuating fluid supply valve, said opening-direction electrical coil selectively operable to electromagnetically pull the spool towards another state corresponding to the opened position of the actuating fluid supply valve.

15. The power module of claim 12, wherein said first and second control valves each include a digitally-controlled three-way valve including a movable magnetically-latchable spool having one end portion and an opposite end portion, a closing-direction electrical coil located proximate the one end portion of the spool, and an opening-direction electrical coil located proximate the opposite end portion of the spool, said closing-direction electrical coil selectively operable to electromagnetically pull the spool towards one state corresponding to the closed position of the first control valve, said opening-direction electrical coil selectively operable to electromagnetically pull the spool towards another state corresponding to the opened position of the first control valve.

16. The power module of claim 12, further including an electronic control unit operable to control the selectable operation of each said electronically-controllable valves.

17. The power module of claim 16, further including an actuating fluid pressure sensor operable to i) sense the pressure of actuating fluid in the actuating fluid storage chamber and ii) provide the electronic control unit with an actuating fluid pressure signal indicative of said pressure, said electronic control unit operable to independently control the operation of the actuating fluid supply valve in response to said actuating fluid pressure signal.

18. The power module of claim 16, further including an actuating fluid pressure sensor operable to i) sense the pressure of actuating fluid in the actuating fluid common rail and ii) provide the electronic control unit with an actuating fluid pressure signal indicative of said pressure, said electronic control unit operable to independently control the operation of the first and second control valves in response to said actuating fluid pressure signal.

19. The power module of claim 16, wherein said electronic control unit further independently controls the operation of the first and second control valves in response to at least one sensed parameter selected from the group of ambient air temperature, ambient barometric pressure, inlet air temperature, inlet air pressure, actuating fluid temperature, actuating fluid pressure, throttle position, power piston position, engine brake signals, starter inputs, and ignition switch position.

20. The power module of claim 12, further including an electronically-controllable hydraulically-actuatable fuel injector extending into the combustion chamber and selectively operable to inject fuel therein.

21. The power module of claim 20, wherein said injector includes an actuating fluid chamber, a piston portion positioned in the actuating fluid chamber, a

check valve movable between a closed position at which the check valve blocks injection of fuel and an opened position at which the check valve opens injection of fuel, and an electronically-controllable magnetically-latchable third control valve arranged in fluid communication between the actuating fluid common rail and the actuating fluid chamber of the injector, said third control valve selectively operable to move between i) a closed position at which the third control valve closes fluid communication between the actuating fluid common rail and the actuating fluid chamber of the injector and opens fluid communication between the actuating fluid drain passage and the actuating fluid chamber of the injector thereby allowing the check valve of the injector to be moved towards its closed position and ii) an opened position at which the third control valve opens fluid communication between the actuating fluid common rail and the actuating fluid chamber of the injector and closes fluid communication between the actuating fluid drain passage and the actuating fluid chamber of the injector thereby allowing the check valve to be hydraulically moved towards its opened position.

22. The power module of claim 21, wherein said injector is a multiple stage injector.

23. The power module of claim 12, wherein said actuating fluid storage chamber is integrally formed with the actuating fluid compressor cell.

24. The power module of claim 12, wherein said actuating fluid storage chamber is connected to the actuating fluid compressor cell.

25. The power module of claim 12, wherein said intake and exhaust valves each further include a return spring operable to bias the respective valve towards its closed position.

26. The power module of claim 12, wherein the actuating fluid compressor cell and the combustion cell are integrally formed with one another by a common housing.

27. The power module of claim 12, wherein the actuating fluid compressor cell and the combustion cell are connected together as a compact unit.

28. The power module of claim 12, wherein the actuating fluid pump piston and the power piston are movable by a common drive device.

29. A power module, comprising:

an air compressor cell defining a variable-volume air compressor chamber, an air supply port, and an air exit port, said air supply port and air exit port each arranged in fluid communication with the air compressor chamber, said air supply port adapted to communicate with a source of supply air;

an air supply valve associated with the air supply port and selectively operable to move between i) a closed position at which the air supply valve closes the air supply port and thereby closes fluid communication between the source of supply air and the air compressor chamber via the air supply port and ii) an opened position at which the supply valve opens the air supply port and thereby opens fluid communication between the source of supply air and the air compressor chamber via the air supply port;

an air pump piston positioned in the air compressor chamber and operable to move between i) an expansion position at which the air compressor chamber reaches its maximum volume and ii) a contraction position at which the air compressor chamber reaches its minimum volume;

a combustion cell defining a variable-volume combustion chamber, separate from the actuating fluid compressor chamber, an air inlet port, an exhaust port, and an actuating fluid common rail, said air inlet port and exhaust port each arranged in fluid communication with the combustion chamber;

an air storage chamber arranged in fluid communication between the air exit port of the air compressor cell and the air intake port of the combustion cell;

an air check valve arranged in fluid communication between said air exit port and the air storage chamber, said air check valve operable to allow only one-way fluid flow from the air compressor chamber to the air storage chamber;

an actuating fluid compressor cell defining a variable-volume actuating fluid compressor chamber and an actuating fluid port arranged in fluid communication with the actuating fluid compressor chamber, said actuating fluid port adapted to communicate with a source of actuating fluid;

an actuating fluid drain passage adapted to be arranged in fluid communication with the source of actuating fluid;

an actuating fluid supply valve arranged in fluid communication between the source of actuating fluid and the actuating fluid port and selectively operable to move between i) a closed position at which the supply valve closes fluid communication between the source of actuating fluid and the actuating fluid compressor chamber via the actuating fluid port and ii) an opened position at which the supply valve opens fluid communication between the source of actuating fluid and the actuating fluid compressor chamber via the actuating fluid port;

an actuating fluid pump piston positioned in the actuating fluid compressor chamber and operable to move therein between i) an expansion position at which the actuating fluid compressor chamber reaches its maximum volume and ii) a contraction position at which the actuating fluid compressor chamber reaches its minimum volume;

an actuating fluid storage chamber arranged in fluid communication between the actuating fluid port of the actuating fluid compressor cell and the actuating fluid common rail;

an actuating fluid check valve arranged in fluid communication between the actuating fluid port of the actuating fluid compressor cell and the actuating fluid storage chamber, said actuating fluid check valve operable to allow only one-way fluid flow from the actuating fluid compressor chamber to the actuating fluid storage chamber;

a hydraulically-actuatable intake valve associated with the air inlet port of the combustion cell and having an actuating fluid chamber and a piston portion positioned in the actuating fluid chamber, said intake valve selectively operable to move between i) a closed position at which the intake valve closes the air inlet port and thereby closes fluid communication between the air storage chamber and the combustion chamber via the air inlet port and ii) an opened position at which the

intake valve opens the air inlet port and thereby opens fluid communication between the air storage chamber and the combustion chamber via the air inlet port;

an electronically-controllable magnetically-latchable first control valve arranged in fluid communication between the actuating fluid common rail and the actuating fluid chamber of the intake valve, said first control valve selectively operable to move between i) a closed position at which the first control valve closes fluid communication between the actuating fluid common rail and the actuating fluid chamber of the intake valve and opens fluid communication between the actuating fluid drain passage and the actuating fluid chamber of the intake valve thereby allowing the intake valve to be moved towards its closed position and ii) an opened position at which the first control valve opens fluid communication between the actuating fluid common rail and the actuating fluid chamber of the intake valve and closes fluid communication between the actuating fluid drain passage and the actuating fluid chamber of the intake valve thereby allowing the intake valve to be hydraulically moved towards its opened position ;

a hydraulically-actuatable exhaust valve associated with the exhaust port of the combustion cell and having an actuating fluid chamber and a piston portion positioned in the actuating fluid chamber, said exhaust valve selectively operable to move between i) a closed position at which the exhaust valve closes the exhaust port and thereby closes fluid communication between the combustion chamber and the exhaust port and ii) an opened position at which the exhaust valve opens the exhaust port and thereby opens fluid communication between the combustion chamber and the exhaust port;

an electronically-controllable magnetically-latchable second control valve arranged in fluid communication between the actuating fluid common rail and the actuating fluid chamber of the exhaust valve, said second control valve selectively operable to move between i) a closed position at which the second control valve closes fluid communication between the actuating fluid common rail and the actuating fluid chamber of the exhaust valve and opens fluid communication between the actuating fluid drain passage and the actuating fluid chamber of the exhaust valve thereby allowing the exhaust valve to be moved towards its closed position and ii) an opened position at which the second control valve opens fluid

communication between the actuating fluid common rail and the actuating fluid chamber of the exhaust valve and closes fluid communication between the actuating fluid drain passage and the actuating fluid chamber of the exhaust valve thereby allowing the exhaust valve to be hydraulically moved towards its opened position; and

a power piston positioned in the combustion chamber and operable to move therein between i) an expansion position at which the combustion chamber reaches its maximum volume and ii) a contraction position at which the combustion chamber reaches its minimum volume.

30. The power module of claim 29, wherein said actuating fluid pump piston is driven by said air pump piston.

31. A power module, comprising:

an air compressor cell defining a variable-volume air compressor chamber, an air supply port, and an air exit port, said air supply port and air exit port each arranged in separate fluid communication with the air compressor chamber, said air supply port adapted to communicate with a source of supply air;

an electronically-controllable magnetically-latchable air supply poppet valve associated with the air supply port, said air supply poppet valve including a magnetically-latchable poppet having an end portion and movable between a closed position and an opened position, a return spring operable to bias the poppet of the air supply poppet valve towards its closed position at which the poppet of the air supply poppet valve closes the air supply port and thereby closes fluid communication between the source of supply air and the air compressor chamber via the air supply port, and an opening-direction electrical coil located proximate the end portion of the poppet, said opening-direction electrical coil selectively operable to electromagnetically pull the poppet of the air supply poppet valve towards its opened position at which the poppet of the air supply poppet valve opens the air supply port and thereby opens fluid communication between the source of supply air and the air compressor chamber via the air supply port;

an air pump piston positioned in the air compressor chamber and operable to reciprocally move between i) an expansion position at which the air compressor chamber reaches its maximum volume and ii) a contraction position at which the air compressor chamber reaches its minimum volume;

a combustion cell defining a variable-volume internal combustion chamber, separate from the actuating fluid compressor chamber, an air inlet port, an exhaust port, and an actuating fluid common rail, said air inlet port and exhaust port each arranged in separate fluid communication with the combustion chamber;

an air storage chamber arranged in fluid communication between the air exit port of the air compressor cell and the air intake port of the combustion cell;

an air check valve arranged in fluid communication between said air exit port and the air storage chamber, said air check valve operable to allow only one-way fluid flow from the air compressor chamber to the air storage chamber;

an actuating fluid compressor cell defining a variable-volume actuating fluid compressor chamber and an actuating fluid port arranged in fluid communication with the actuating fluid compressor chamber, said actuating fluid port adapted to communicate with a source of actuating fluid;

an actuating fluid drain passage adapted to be arranged in fluid communication with the source of actuating fluid;

an electronically-controllable magnetically-latchable two-way actuating fluid supply valve arranged in fluid communication between the source of actuating fluid and the actuating fluid port, said actuating fluid supply valve including a magnetically-latchable spool having one end portion and an opposite end portion and movable between a closed position and an opened position, a closing-direction electrical coil located proximate the one end portion of the spool, and an opening-direction electrical coil located proximate the opposite end portion of the spool, said closing-direction electrical coil selectively operable to electromagnetically pull the spool of the actuating fluid supply valve towards its closed position at which the spool of the actuating fluid supply valve closes fluid communication between the source of actuating fluid and the actuating fluid compressor chamber via the actuating fluid port, said opening-direction electrical coil selectively operable to electromagnetically pull the spool of the actuating fluid supply valve towards its

opened position at which the spool of the actuating fluid supply valve opens fluid communication between the source of actuating fluid and the actuating fluid compressor chamber via the actuating fluid port;

an actuating fluid pump piston positioned in the actuating fluid compressor chamber and operable to reciprocally move therein between i) an expansion position at which the actuating fluid compressor chamber reaches its maximum volume and ii) a contraction position at which the actuating fluid compressor chamber reaches its minimum volume;

an actuating fluid storage chamber arranged in fluid communication between the actuating fluid port of the actuating fluid compressor cell and the actuating fluid common rail;

an actuating fluid check valve arranged in fluid communication between the actuating fluid port of the actuating fluid compressor cell and the actuating fluid storage chamber, said actuating fluid check valve operable to allow only one-way fluid flow from the actuating fluid compressor chamber to the actuating fluid storage chamber;

a hydraulically-actuatable intake poppet valve associated with the air inlet port of the combustion cell and having an actuating fluid chamber and a piston portion positioned in the actuating fluid chamber, said intake poppet valve selectively operable to reciprocally move between i) a closed position at which the intake poppet valve closes the air inlet port and thereby closes fluid communication between the air storage chamber and the combustion chamber via the air inlet port and ii) an opened position at which the intake poppet valve opens the air inlet port and thereby opens fluid communication between the air storage chamber and the combustion chamber via the air inlet port;

an electronically-controllable magnetically-latchable three-way first control valve arranged in fluid communication between the actuating fluid common rail and the actuating fluid chamber of the intake valve, said first control valve including a magnetically-latchable spool having one end portion and an opposite end portion and movable between a closed position and an opened position, a closing-direction electrical coil located proximate the one end portion of the spool, and an opening-direction electrical coil located proximate the opposite end portion of the spool, said

closing-direction electrical coil selectively operable to electromagnetically pull the spool towards its closed position at which the spool of the first control valve closes fluid communication between the actuating fluid common rail and the actuating fluid chamber of the intake poppet valve and opens fluid communication between the actuating fluid drain passage and the actuating fluid chamber of the intake poppet valve thereby allowing the intake poppet valve to be moved towards its closed position, said opening-direction electrical coil selectively operable to electromagnetically pull the spool towards its opened position at which the spool of the first control valve opens fluid communication between the actuating fluid common rail and the actuating fluid chamber of the intake poppet valve and closes fluid communication between the actuating fluid drain passage and the actuating fluid chamber of the intake poppet valve thereby allowing the intake poppet valve to be hydraulically moved towards its opened position;

a hydraulically-actuatable exhaust poppet valve associated with the exhaust port of the combustion cell and having an actuating fluid chamber and a piston portion positioned in the actuating fluid chamber, said exhaust poppet valve selectively operable to reciprocally move between i) a closed position at which the exhaust poppet valve closes the exhaust port and thereby closes fluid communication between the combustion chamber and the exhaust port and ii) an opened position at which the exhaust poppet valve opens the exhaust port and thereby opens fluid communication between the combustion chamber and the exhaust port;

an electronically-controllable magnetically-latchable three-way second control valve arranged in fluid communication between the actuating fluid common rail and the actuating fluid chamber of the exhaust poppet valve, said second control valve including a magnetically-latchable spool having one end portion and an opposite end portion and movable between a closed position and an opened position, a closing-direction electrical coil located proximate the one end portion of the spool, and an opening-direction electrical coil located proximate the opposite end portion of the spool, said closing-direction electrical coil selectively operable to electromagnetically pull the spool towards its closed position at which the spool of the second control valve closes fluid communication between the actuating fluid common rail and the actuating fluid chamber of the exhaust poppet valve and opens

fluid communication between the actuating fluid drain passage and the actuating fluid chamber of the exhaust poppet valve thereby allowing the exhaust poppet valve to be moved towards its closed position, said opening-direction electrical coil selectively operable to electromagnetically pull the spool towards its opened position at which the spool of the second control valve opens fluid communication between the actuating fluid common rail and the actuating fluid chamber of the exhaust poppet valve and closes fluid communication between the actuating fluid drain passage and the actuating fluid chamber of the exhaust poppet valve thereby allowing the exhaust poppet valve to be hydraulically moved towards its opened position; and

a power piston positioned in the combustion chamber and operable to reciprocally move therein between i) an expansion position at which the combustion chamber reaches its maximum volume and ii) a contraction position at which the combustion chamber reaches its minimum volume.

32. An internal combustion engine, comprising:

a plurality of power modules connected to generate work together wherein each power module separately includes an air compressor cell defining a variable-volume air compressor chamber, an air supply port, and an air exit port, said air supply port and air exit port each arranged in fluid communication with the air compressor chamber, said air supply port adapted to communicate with a source of supply air; an air supply valve associated with the air supply port and selectively operable to move between i) a closed position at which the air supply valve closes the air supply port and thereby closes fluid communication between the source of supply air and the air compressor chamber via the air supply port and ii) an opened position at which the air supply valve opens the air supply port and thereby opens fluid communication between the source of supply air and the air compressor chamber via the air supply port; an air pump piston positioned in the air compressor chamber and operable to move between i) an expansion position at which the air compressor chamber reaches its maximum volume and ii) a contraction position at which the air compressor chamber reaches its minimum volume; a combustion cell defining a variable-volume combustion chamber separate from the air compressor

chamber, an air intake port, and an exhaust port, said air intake port and exhaust port each arranged in fluid communication with the combustion chamber; an air storage chamber arranged in fluid communication between the air exit port of the air compressor cell and the air intake port of the combustion cell; an intake valve associated with the air intake port of the combustion cell and selectively operable to move between i) a closed position at which the intake valve closes the air intake port and thereby closes fluid communication between the air storage chamber and the combustion chamber via the air intake port and ii) an opened position at which the intake valve opens the air intake port and thereby opens fluid communication between the air storage chamber and the combustion chamber via the air intake port; an exhaust valve associated with the exhaust port of the combustion cell and selectively operable to move between i) a closed position at which the exhaust valve closes the exhaust port and thereby closes fluid communication between the combustion chamber and the exhaust port and ii) an opened position at which the exhaust valve opens the exhaust port and thereby opens fluid communication between the combustion chamber and the exhaust port; and a power piston positioned in the respective combustion chamber and operable to move therein between i) an expansion position at which the respective combustion chamber reaches its maximum volume and ii) a contraction position at which the respective combustion chamber reaches its minimum volume; wherein said air compressor chamber and air storage chamber of each power module are isolated from fluid communication and independently operable with respect to the air compressor chamber and air storage chamber of any other said power module of the internal combustion engine.

33. The internal combustion engine of claim 32, further including a separate electronic control unit associated with each power module, each electronic control unit operable to selectively and independently control the operation of the respective air supply valve with digital pulses of electrical current.

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34. The internal combustion engine of claim 33, further including an air pressure sensor associated with each power module, said air pressure sensor operable

to sense the pressure of air in the respective air storage chamber and provide the respective electronic control unit with a signal indicative of such pressure, said respective electronic control unit operable to move the respective air supply valve to its opened position in response to said pressure being below a threshold air pressure, said respective electronic control unit operable to move the respective air supply valve to its closed position in response to said pressure being at least the threshold air pressure.

35. The internal combustion of claim 32, wherein each control unit is operable to selectively and independently control the operation of the respective air supply valve in response to at least one sensed parameter selected from the group of air temperature, air manifold pressure, actuating fluid temperature, actuating fluid pressure, barometric pressure, throttle position, power piston position, engine brake signals, starter inputs, and ignition switch position.

36. The internal combustion engine of claim 32, wherein the air compressor cell and combustion cell of each power module are located adjacent to one another.

37. The internal combustion engine of claim 32, wherein said power modules are arranged substantially in-line relative to one another.

38. The internal combustion engine of claim 32, wherein the air compressor cells are arranged in an alternating and substantially in-line pattern with respect to the combustion cells.

39. An internal combustion engine, comprising:

a plurality of power modules connected to generate work together wherein each power module separately includes an actuating fluid compressor cell defining a variable-volume actuating fluid compressor chamber and an actuating fluid port arranged in fluid communication with the actuating fluid compressor chamber, said actuating fluid port adapted to communicate with a source of actuating fluid; an

actuating fluid drain passage adapted to be arranged in fluid communication with the source of actuating fluid; an actuating fluid supply valve arranged in fluid communication between the source of actuating fluid and the actuating fluid port and selectively operable to move between i) a closed position at which the supply valve closes fluid communication between the source of actuating fluid and the actuating fluid compressor chamber via the actuating fluid port and ii) an opened position at which the supply valve opens fluid communication between the source of actuating fluid and the actuating fluid compressor chamber via the actuating fluid port; an actuating fluid pump piston positioned in the actuating fluid compressor chamber and operable to move therein between i) an expansion position at which the actuating fluid compressor chamber reaches its maximum volume and ii) a contraction position at which the actuating fluid compressor chamber reaches its minimum volume; a combustion cell defining a variable-volume combustion chamber, separate from the actuating fluid compressor chamber, an air inlet port, an exhaust port, and an actuating fluid common rail, said air inlet port and exhaust port each arranged in fluid communication with the combustion chamber; an actuating fluid storage chamber arranged in fluid communication between the actuating fluid port of the actuating fluid compressor cell and the actuating fluid common rail; a hydraulically-actuatable intake valve associated with the air inlet port of the combustion cell and having an actuating fluid chamber and a piston portion positioned in the actuating fluid chamber, said intake valve selectively operable to move between i) a closed position at which the intake valve closes the air inlet port and thereby closes fluid communication between the air storage chamber and the combustion chamber via the air inlet port and ii) an opened position at which the intake valve opens the air inlet port and thereby opens fluid communication between the air storage chamber and the combustion chamber via the air inlet port; an electronically-controllable magnetically-latchable first control valve arranged in fluid communication between the actuating fluid common rail and the actuating fluid chamber of the intake valve, said first control valve selectively operable to move between i) a closed position at which the first control valve closes fluid communication between the actuating fluid common rail and the actuating fluid chamber of the intake valve and opens fluid communication between the actuating

fluid drain passage and the actuating fluid chamber of the intake valve thereby allowing the intake valve to be moved towards its closed position and ii) an opened position at which the first control valve opens fluid communication between the actuating fluid common rail and the actuating fluid chamber of the intake valve and closes fluid communication between the actuating fluid drain passage and the actuating fluid chamber of the intake valve thereby allowing the intake valve to be hydraulically moved towards its opened position; a hydraulically-actuatable exhaust valve associated with the exhaust port of the combustion cell and having an actuating fluid chamber and a piston portion positioned in the actuating fluid chamber, said exhaust valve selectively operable to move between i) a closed position at which the exhaust valve closes the exhaust port and thereby closes fluid communication between the combustion chamber and the exhaust port and ii) an opened position at which the exhaust valve opens the exhaust port and thereby opens fluid communication between the combustion chamber and the exhaust port; an electronically-controllable magnetically-latchable second control valve arranged in fluid communication between the actuating fluid common rail and the actuating fluid chamber of the exhaust valve, said second control valve selectively operable to move between i) a closed position at which the second control valve closes fluid communication between the actuating fluid common rail and the actuating fluid chamber of the exhaust valve and opens fluid communication between the actuating fluid drain passage and the actuating fluid chamber of the exhaust valve thereby allowing the exhaust valve to be moved towards its closed position and ii) an opened position at which the second control valve opens fluid communication between the actuating fluid common rail and the actuating fluid chamber of the exhaust valve and closes fluid communication between the actuating fluid drain passage and the actuating fluid chamber of the exhaust valve thereby allowing the exhaust valve to be hydraulically moved towards its opened position; and a power piston positioned in the combustion chamber and operable to move therein between i) an expansion position at which the combustion chamber reaches its maximum volume and ii) a contraction position at which the combustion chamber reaches its minimum volume; wherein said actuating fluid compressor chamber and actuating fluid storage chamber of each power module are isolated from fluid communication and

independently operable with respect to the actuating fluid compressor chamber and actuating fluid storage chamber of any other said power module of the internal combustion engine.

40. The internal combustion engine of claim 39, wherein said actuating fluid compressor cell and combustion cell of each power module are located adjacent to one another.

41. The internal combustion engine of claim 39, wherein said power modules are arranged substantially in-line relative to one another.

42. The internal combustion engine of claim 39, wherein the actuating fluid compressor cells are arranged in an alternating and substantially in-line pattern with respect to the combustion cells.

43. A two-stroke cycle power module, comprising:

a rotatable crankshaft;

a combustion chamber;

a movable power piston positioned in the combustion chamber and coupled to the crankshaft for movement therewith;

an electronically-controllable hydraulically-actuatable fuel injector extending into the combustion chamber and selectively operable to inject fuel therein;

an electronically-controllable hydraulically-actuatable intake valve selectively

operable to admit air into the combustion chamber; and

an electronically-controllable hydraulically-actuatable exhaust valve selectively operable to vent exhaust gas from the combustion chamber, wherein said crankshaft is selectively rotatable in one angular direction and a reverse angular direction in response to selectable timing and sequence of operation of the intake and exhaust valves and the fuel injector relative to the position of the power piston.

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44. A method of operating a two-stroke cycle power module having a rotatable crankshaft; an air compressor cell defining a variable-volume air compressor chamber, an air supply port, and an air exit port, said air supply port and air exit port each arranged in fluid communication with the air compressor chamber, said air supply port adapted to communicate with a source of supply air; an air supply valve associated with the air supply port and selectively operable to move between i) a closed position at which the air supply valve closes the air supply port and thereby closes fluid communication between the source of supply air and the air compressor chamber via the air supply port and ii) an opened position at which the air supply valve opens the air supply port and thereby opens fluid communication between the source of supply air and the air compressor chamber via the air supply port; an air pump piston positioned in the air compressor chamber and operable to move between i) an expansion position at which the air compressor chamber reaches its maximum volume and ii) a contraction position at which the air compressor chamber reaches its minimum volume; a combustion cell defining a variable-volume combustion chamber separate from the air compressor chamber, an air intake port, and an exhaust port, said air intake port and exhaust port each arranged in fluid communication with the combustion chamber; an air storage chamber arranged in fluid communication between the air exit port of the air compressor cell and the air intake port of the combustion cell; an intake valve associated with the air intake port of the combustion cell and selectively operable to move between i) a closed position at which the intake valve closes the air intake port and thereby closes fluid communication between the air storage chamber and the combustion chamber via the air intake port and ii) an opened position at which the intake valve opens the air intake port and thereby opens fluid communication between the air storage chamber and the combustion chamber via the air intake port; an exhaust valve associated with the exhaust port of the combustion cell and selectively operable to move between i) a closed position at which the exhaust valve closes the exhaust port and thereby closes fluid communication between the combustion chamber and the exhaust port and ii) an opened position at which the exhaust valve opens the exhaust port and thereby opens fluid communication between the combustion chamber and the exhaust port; and a power piston positioned in the combustion chamber and coupled

to the crankshaft for movement therewith, said power piston operable to move in the combustion chamber between i) an expansion position at which the combustion chamber reaches its maximum volume corresponding to a 180° angular position of the crankshaft and ii) a contraction position at which the combustion chamber reaches its minimum volume corresponding to a 0° angular position of the crankshaft, said method comprising the steps of:

moving the power piston from its contraction position and towards its expansion position;

opening the exhaust valve when the power piston has been moved to a first position corresponding to a first angular position of the crankshaft;

opening the intake valve when the power piston has been moved to a second position corresponding to a second angular position of the crankshaft;

moving the power piston to its expansion position;

moving the power piston from its expansion position and towards its contraction position;

closing the exhaust valve when the power piston has been moved to a third position corresponding to a third angular position of the crankshaft;

closing the intake valve when the power piston has been moved to a fourth position corresponding to a fourth angular position of the crankshaft; and

moving the power piston to its contraction position.

45. The method of claim 44, wherein the angular distance between the first and fourth angular positions is about 80°.

46. The method of claim 44, wherein the first angular position of the crankshaft is about 140°, the second angular position of the crankshaft is about 160°, the third angular position of the crankshaft is about 200°, and the fourth angular position of the crankshaft is about 220°.

47. The method of claim 44, wherein during operation of the power module the combustion chamber has a peak fluid pressure of about 13,790 kPa (about 2000 psi) when the power piston is at its contraction position.

48. The method of claim 44, wherein during operation of the power module the combustion chamber has a residual fluid pressure greater than atmospheric pressure when the power piston is at its expansion position.

49. The method of claim 48, wherein the residual fluid pressure in the combustion chamber is at least about 138 kPa (about 20 psi).

50. The method of claim 50, wherein the residual fluid pressure in the combustion chamber is in the range of about 138 to 207 kPa (about 20 to 30 psi).